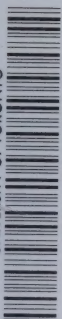


FACULTY OF DENTISTRY LIBRARY  
UNIVERSITY OF TORONTO



3 1761 03912941 6

# ORAL HYGIENE

—  
BY  
SIR WALLACE



BAM 0234

# ORAL HYGIENE



# ORAL HYGIENE

BY

J. SIM WALLACE, D.Sc., M.D., L.D.S.

LECTURER ON PREVENTIVE DENTISTRY, KING'S COLLEGE HOSPITAL  
FORMERLY DENTAL SURGEON AND LECTURER ON DENTAL SURGERY AND PATHOLOGY,  
LONDON HOSPITAL



LONDON

BAILLIÈRE, TINDALL AND COX

8, HENRIETTA STREET, COVENT GARDEN, W.C. 2

1923

8

PRINTED IN GREAT BRITAIN.

## PREFACE

THREE of the four communications which go to form this little book have already been published. The first was a paper read in the Section of Physiology at the Annual Meeting of the British Medical Association (*British Medical Journal*, October 29, 1921); the second a contribution to a joint discussion in the Section of Diseases of Children (with Physiology) at the Annual Meeting of the British Medical Association in July, 1922 (*British Medical Journal*, November 4, 1922); the third a paper contributed to the *Medical Press and Circular*, and published in that journal November 1, 8, and 15, 1922. The concluding paper was written in response to a courteous invitation from the Secretary of the Odontological Section of the Royal Society of Medicine to read a paper on Preventive Dentistry. It was read on May 28 of this year, and was apparently particularly well received. When I got the proofs of the paper I noted that certain alterations had been made which did not altogether please me. The editor of the section also called to see me with regard to the deletion of a paragraph which I could not see my way to permit. I was then written to by the editor of the *Proceedings* of the Royal Society of Medicine, requesting from me the alterations of a very few words. I gave way with regard to his suggested alterations more or less completely, and having done so received a letter from him with best thanks for my prompt return of proof revised for press, and for my patience and courtesy in dealing with his

criticisms. Just before the paper was going to press, however, I was written to by him asking me to allow the paper to be printed without the paragraph, and informing me that the Council of the Odontological Section had "definitely decided" not to include it in its *Proceedings*. How this came about I may or may not know ; in any case, as has been previously indicated, I could not see my way to sanction the deletion of the paragraph. The suggestion that the paragraph was political, and so should not appear in the *Proceedings* did not seem to bear analysis. There was originally no political intent, though perhaps politics may now be grafted on to it (p. 71). My intention was wholly directed to vindicating the competence and good work which had been done by research workers in the dental profession, and to turn the tables in a jocular, and so really gentle, way on those who had appointed a committee which in my opinion, and presumably in the opinion of the great majority of my colleagues, undoubtedly showed marked contempt for the dental profession. Who was responsible I do not know. All I know is that the Medical Research Council in consultation with the Ministry of Health appointed the committee. But if *any* one or *any group* of individuals, especially in responsible positions, treats the dental profession with contempt, surely a passing paragraph, from one who does not *wish* to take up politics, vindicating the honour of his own profession, is not only permissible but eminently desirable. The methods and qualifications as well as the actual scientific reports are fitting subjects for fair and effective criticism, and satisfactory progress will be difficult without it. *La critique est la vie de la science.*

J. SIM WALLACE.

September 27, 1923.

# CONTENTS

| CHAPTER                                                                                              | PAGE |
|------------------------------------------------------------------------------------------------------|------|
| I. THE PHYSIOLOGY OF ORAL HYGIENE - -                                                                | 1    |
| II. VITAMINS AND DENTAL HYPOPLASIA - -                                                               | 13   |
| III. ELEMENTARY LECTURE ON FOOD AND FEEDING<br>IN RELATION TO THE DISEASES OF THE<br>TEETH - - - - - | 20   |
| IV. OBSERVATIONS ON THE PROGRESS OF PREVENTIVE<br>DENTISTRY - - - - -                                | 43   |



# ORAL HYGIENE

## CHAPTER I

### THE PHYSIOLOGY OF ORAL HYGIENE

To understand properly the physiology of oral hygiene it is necessary to refer briefly to the physiology of mastication, for, although the chief function of mastication is the preliminary preparation of food in order to facilitate its digestion, it has a secondary function in that when suitable foods are masticated it cleans the teeth and facilitates the action of the saliva in doing likewise. It should be noted, however, that many foodstuffs which are consumed at the present day are hardly subjected to the process of mastication at all. The food is simply taken into the mouth, receives a general squash between the teeth, or between the dorsum of the tongue and the hard palate, and is then swallowed. This method of mastication, if mastication it can be called, is as a rule adopted for custards, fine meal porridge, soft puddings, and soft non-fibrous foods generally.

When there is a certain amount of crisp, spongy, or fibrous matter in the foodstuff, then the process is essentially different, and mastication is performed in a more thorough manner. In this latter case the food is crushed and torn between, and heaped on to the masticating surfaces of the teeth by the muscular contractions of the

tongue, cheeks, and lips, and by the motions of the lower jaw. During comminution between the teeth, the juices of the foodstuffs, the saliva which becomes incorporated, and the suspended non-fibrous part, are pressed out from the fibres and gradually collect during the process on the middle of the dorsum of the tongue, which is gradually hollowed out for the reception of such food, and this part is then swallowed. The fibrous part of the food, however, is subjected again and again to the crushing and disintegration between the teeth. The rubbing of the food on the teeth, the motions of the tongue, lips, cheeks, and mandible materially aid in the mechanical cleansing of the teeth and gums, provided suitable food for this purpose is eaten. When for any reason mastication is not performed on one side of the mouth, the teeth on that side become coated with mucus, tartar, and food débris. It is evident, therefore, that mastication of fibrous food is conducive to dental hygiene.

Now let me direct attention more particularly to mucus and saliva in regard to oral hygiene. I shall do so at some length because the subject is not referred to in physiological textbooks. Physiologists hardly seem even yet to realize that oral hygiene is a physiological process, and that all the glands opening into the mouth, together with their secretions, are specially adapted for the maintenance of oral hygiene, and that these secretions are scarcely, if at all, of importance for any other function.

#### MUCUS.

From the point of view of the oral hygienist, the supposed function of the mucus for lubricating the bolus

of food so as to facilitate its passage down the œsophagus is whimsical, for inasmuch as the function of mastication is to comminute the food, and reduce anything in the nature of a bolus to a liquid or semi-liquid state before it passes to the back of the dorsum of the tongue, there is no bolus to lubricate. The mucus and saliva are thoroughly incorporated with the food, and consequently the semi-liquid food does not require lubrication. Just as the function of the mucus in the bronchial tubes is to keep these tubes clean, so the essential function of the oral mucus is to keep the mouth clean. Mucus is a liquid, tenacious and ropy in its nature, which under certain circumstances clings to hard substances. Chemically, perhaps, its best-known characteristic is that it forms a flocculent precipitate when treated with acids. These properties of mucus are well known. The following quotation from the work of Professor W. E. Gies and his collaborator, Dr. Lothrop, will indicate some further characteristics :

“Mucin occurs in saliva, and apparently also on dental surfaces, primarily as acid salts in concentrated colloidal solution. When viscid mucinous coatings are treated with basic material, such as carbonate of an alkali or an earthy element, the mucin mass becomes superficially more smeary and slippery by reason of the production of more soluble mucin salts at the surface. Complete mechanical removal of a mucin plaque from a tooth is facilitated by the addition of a basic material that renders the mucin superficially more viscous, but the slippery surface thus produced may make the application of considerable friction necessary for

the detachment of the plaque. On the other hand, when a viscid mucinous deposit is treated with acid material, the mucin mass is completely disintegrated by a curdling or agglutinative process, the particles are devoid of adhesiveness to smooth surfaces, stickiness disappears because of the precipitation of caseous mucin itself, and the entire disorganized mass may be readily flushed away."

A consideration of these properties of mucus leads us to the conclusion that it is quite ingeniously suited for keeping the mouth free from the undue lodgment of food particles, when the foods are not converted by artificial means into some bland pap-like form which stultifies efficient mastication, negatives "considerable friction," and precludes the possibility of its being disintegrated so that it may be readily flushed away. It matters but little whether the chemical reaction of the food is neutral or alkaline, for during the mastication of food the saliva becomes alkaline if in its resting state it is acid, and the slippery state of the mucous coating on the teeth (and gums) is assured, while the ropiness of the mucus is left unimpaired.

On the other hand, if the food is more acid than can be neutralized by the copious flow of alkaline saliva, which it stimulates, the mucous films themselves are disintegrated and easily removed by the saliva and mucus after the acid has been swallowed. Thus, then, the mucus has not only the power of facilitating the removal of food particles and shreds which have been disintegrated by mastication, but it has also, under certain dietetic conditions, the property of being disintegrated and carrying its own disintegrated

self away. Under unsatisfactory dietetic conditions—that is, when the food is habitually alkaline and so soft as not to stimulate mastication—the mucous coating on the teeth may remain too long, stagnate, and become infiltrated with the salts of the saliva; that is to say, tartar may be formed; or, if the food is of a carbohydrate nature and of a sticky character, it may be rapidly converted into lactic acid by bacteria, decalcification of the enamel may take place, and dental caries may be initiated. Should, however, the mucus not be saturated with carbohydrates of an impermeable and easily fermentable nature, the bacteria of the mouth slowly disintegrate the mucous coatings on the teeth and facilitate its removal on those surfaces of the teeth where it has not been removed by disintegration or considerable friction. It is quite possible, too, that the ptyalin in the saliva may digest the carbohydrate radical in the mucus, just as trypsin does. Why, otherwise, should we have a saliva rich in ptyalin poured out when sugar is taken in the mouth?

When we consider these facts we see that mucus is ingeniously devised for oral hygiene, and it is not devised for the lubrication of the bolus of food to facilitate its transmission to the stomach, nor is it devised, as has been suggested, to keep the numerous boluses of food in the stomach from the action of the hydrochloric acid, so that the ptyalin may have a chance of converting the starch in the boluses. Indeed, it seems much more probable that the thorough incorporation of food with mucus facilitates the penetration of the hydrochloric acid throughout the whole of the contents of the stomach after a meal, and

possibly this is one of the reasons why a meal of such a physical consistency as demands mastication is more quickly and satisfactorily digested than a meal of a similar nature which has been reduced to a pap-like form before it is taken into the mouth.

#### SALIVA.

It seems to me more than probable that physiologists will require to reconsider their teachings with regard to the function of the saliva. Hitherto they have looked upon it as the first of the digestive juices, and the salivary glands have been regarded as the first of the digestive glands. Some physiologists realize that the digestion of starch is not *the* function of the saliva; at least, Professor Noël Paton considers that its more important function is mechanical (to facilitate speaking, eating, etc.). I shall try to indicate what the function of the saliva really is, but if we have not discovered the function of the saliva surely the sooner physiologists set about discovering it the better. For quite a number of years I have studied physiological problems because of their importance with regard to human welfare, and have come to the conclusion that to all intents and purposes the saliva is not a digestive juice, but that it is practically wholly for the purposes of oral hygiene. The older physiologists based their ideas on the fact that ptyalin has the power of converting cooked starch into achrodextrine and maltose. But many questions arise which would appear to throw considerable doubt upon regarding this as the chief function of saliva. That the digestion of uncooked starch is practically

negligible is admitted by them ; indeed we are told that ptyalin does not digest uncooked starch (Halliburton, F. A. Bainbridge, and J. Ackworth Menzies). If this be so, we may ask why ptyalin exists in the saliva of animals at all. Is it conceded that the saliva is not a digestive juice in animals ? Again, it has never been contended that ptyalin digests sugar, but sugar stimulates a relatively violent flow of saliva rich in ptyalin. Why, too, should ptyalin exist in the saliva from birth, as we are told by some physiologists ? Oral hygiene is no doubt necessary with a milk diet, but are we to believe that ptyalin is there to digest starch which normally is not present ?

Again, why is starch, immediately it has been masticated and mixed with the saliva, transferred at once to the stomach, where the conditions are so frequently such that the digestion of starch by the ptyalin is immediately arrested, or if it is not immediately arrested, it soon becomes so ? Physiologists have, of course, long recognized this supposed delinquency of Nature, and attempts have been made to explain how ptyalin may have some reasonable time to digest starch before the contents of the stomach become sufficiently acid to arrest the action of ptyalin. Thus, for example, some physiologists (Bainbridge and Menzies) say: "The food, after a meal is taken, forms a compact mass in the stomach, and the hydrochloric acid of the gastric juice penetrates comparatively slowly into this mass." It is only, of course, a pure supposition to say that the food forms a compact mass in the stomach ; nevertheless, they evidently imagine not only that the food passes down the œsophagus in bolus form, but

that the various boluses become one glorified bolus in the stomach.

It is significant that these physiologists never seem to refer to the fact that the contents of the stomach may be acid from the very beginning of a meal. A meal may commence with acid *hors d'œuvre*, the bit of fish which follows may be served with lemon juice, meat may be eaten with salad well seasoned with vinegar, and stewed or raw fruit or both may complete the meal with a further supply of acid, while acid mineral or alcoholic beverages, which are sometimes supposed to stimulate digestion, may, and very frequently do, accompany the meal at various stages. Nevertheless, I do not know that we are told that acids taken in these ways interfere with the digestion except among dyspeptics. Indeed, Professor Pavlov, speaking of the reaction of the food, says: "It is apparent that acidity enjoys a special preference in the human taste. . . . These facts are all physiologically comprehensible when we know that an acid reaction is not only necessary for an efficient action of the peptic ferment, but is at the same time the strongest excitant of the pancreatic gland."

Another point on which there seems to be confusion is with regard to the medium most suitable for the digestion of starch. According to Bainbridge and Menzies, "the digestive action of ptyalin on starch is most energetic in a neutral medium." According to Foster, "the action of saliva on starch is favoured by a slightly alkaline medium." It is curious how this is always referred to as if the slight difference in the reaction of the saliva were

really of considerable importance in digestion. I have frequently tested the reaction of saliva between meals, but certainly am unable to draw the inference that the liquefaction of starch is at all influenced in any practical way by the reaction of such saliva. On the other hand, the fact that the saliva becomes very distinctly alkaline when food is eaten, and for some considerable time after it is swallowed, seems to the older physiologists unworthy of being mentioned.

To us who think that oral hygiene should be at least as common in man as it is in animals, all these apparently confusing and inexplicable facts have a simple explanation. The marked alkalinity of the saliva when food is taken has a significance in that it is important that it should have that reaction while the mucus is specially required for removing food particles from the mouth. If the saliva were sufficiently acid the mucus could not function in this way. Moreover, the acids which so commonly accompany foods might decalcify the teeth. On the other hand, the reaction of the saliva between meals is of practically no importance at all, because the conversion of starch in the mouth into soluble starch proceeds to all intents and purposes sufficiently satisfactorily, whether the saliva be neutral or faintly acid or faintly alkaline to litmus. It has been the subject of much contention, possibly on account of its lack of importance, whether acidity or alkalinity of the saliva was the more unfavourable to the inception of dental caries. The slight acidity of the saliva between meals may be important because of its favouring the liquefying rather than the acid-forming

bacteria, but the greater power of an alkaline saliva in neutralizing acid formed by bacteria may at least equally help to prevent caries. The point is not settled.

Towards the beginning of this paper I suggested a use for the ptyalin when sugar is taken into the mouth, and to those who appreciate why sugar is liable to cause dental caries the reason for a copious flow of saliva when sugar is eaten is obvious. Similarly, the desirability of a copious flow of alkaline saliva when acids are taken into the mouth is equally obvious if we value the preservation of the teeth; but why an alkaline saliva should be thought desirable for digestion if acid is "necessary for the efficient action of the peptic ferment, and at the same time the strongest excitant of the pancreatic gland," I fail to see.

While we are regaled with the importance of ptyalin for the digestion of starch, little is told us of the functions of the salts in the saliva, but they, too, are obviously of importance from the point of view of oral hygiene and the preservation of the teeth. Dr. Joseph Head made the important observation that when the superficial layer of enamel of the teeth has been slightly softened by acid this enamel can be rehardened by immersion in saliva, and thus it would appear that the salts in the saliva have an important restorative value as well as being prophylactic in function with regard to dental caries.

The saliva contains something more—amœboid phagocytic cells, the so-called salivary corpuscles. They may be regarded as the scavengers of the mouth, and, as far as we can surmise, their function is simply oral hygiene. We are told that they are probably derived from the

tonsils (Halliburton), and, although we might expect that lymphoid cells derived from the tonsils would pass down the throat rather than come forward and mix with the saliva, I at least have not seen reference to any experiment or observations to excuse the idea that they come forward into the mouth. The late Professor G. V. Black made a careful examination of the lymphatics surrounding the necks of the teeth, and refers to a portion of the connective tissue in immediate conjunction with the tooth, which is not covered by the epithelium, and says: "It seems to be through this space that the cells—the so-called salivary corpuscles found under the free border of the gingiva—pass." "These may be found at any time under the healthy gingiva, and their numbers are augmented with every irritation of the membrane."

It has always appeared to me that the only satisfactory method of controlling the bacteria in the sulcus between the gingival margin and the tooth is by means of these phagocytic corpuscles. If we admit that the salivary corpuscles exude primarily into this sulcus, we observe at once their importance in oral hygiene, and—in passing, it may be said—the value of masticating food of such a nature as will cause an irritation, or rather stimulation of the periodontal membrane, and thus assure a sufficient supply of these scavengers and thereby prevent the onset of pyorrhœa.

All things considered, it appears that the function of the saliva is, *par excellence*, oral hygiene, and no matter whether the food passes into the mouth and down the œsophagus in the ordinary way or whether the food passes

up from the stomach and out of the mouth, it may in general be said that the saliva is secreted in quality and quantity proportionate to the needs of the food, to expel the food as completely as possible from the mouth. I need hardly mention that although a copious flow of saliva is induced by vomiting, even physiologists of the old school could scarcely claim that under these circumstances the saliva was to be regarded as the first of the digestive juices.

I have put forward the preceding observations to induce physiologists to take up this subject, and to give an authoritative lead. For without this the rank and file of the medical profession cannot be expected to teach the public the new ideas with regard to oral hygiene consistently, and until the function of the saliva is properly taught the valuable work which has been and is being done by medical officers of health and health workers will have but little chance of achieving its beneficent results.

## CHAPTER II

### VITAMINS AND DENTAL HYPOPLASIA

IDEAS with regard to the causation of rickets have recently been considerably influenced by the supposition that fat-soluble A played an important rôle in the development of the teeth. That lack of this vitamin cannot now be regarded as the cause of rickets is generally admitted; nevertheless, the authors of the theory that absence of fat-soluble A causes dental hypoplasia have not stated clearly that they have now completely abandoned this idea. In a recent communication Mrs. Mellanby admits that there are "certainly" other causes of hypoplasia, but we want to know whether lack of fat-soluble A in the diet can be supposed to cause hypoplasia as frequently as does measles or scarlet fever, or for that matter any other single disease which may affect the life-history of the amyloblasts or other epithelial cells.

The experiments and suppositions on which the vitamin theory rested never misled those who were well acquainted with the facts concerning the development of the teeth, but they certainly seemed to impress many outside the dental profession.

It may seem to enhance the importance of vitamins to imbue them with marvellous powers. If it is possible to

depict an abject animal *in extremis*, and then with the aid of minute doses of the required vitamin rejuvenate the animal as if by magic, then of course a sensational impression is made. Such results may well be true with regard to beri-beri and other deficiency diseases, but the attempt to claim that totally different diseases are preventable or curable in a similar way seems hardly justifiable. We have been rather regaled with "the importance of the infinitely little" when the wonderful powers of a vitamin are to be shown on a graph or a screen; but when it is pointed out that children in these days are apparently more richly fed with regard to fat-soluble A than in past ages, it is openly proclaimed that an *abundant supply* of this vitamin is necessary, and something containing 250 times the fat-soluble A found in milk or butter is recommended to save our children from rickets, and the teeth from hypoplasia and dental caries. Even then clinicians often fail to note the marvellous effects claimed without a properly balanced diet, sunlight, and general hygienic conditions. Again, it may be possible to deprive puppies of calcium, phosphorus, and substances necessary for their metabolism in a laboratory so completely that the development of the teeth may be interfered with: but is there any evidence that this ever occurs among children so long as they are getting even a bare sufficiency of protein under any existing scheme of dietary, however eccentric it may be? The quantity of protein and the other ordinary constituents of the diet is massive; the quantity of fat-soluble A, if it be a vitamin, is negligible, for, as is generally recognized and as has been explicitly

stated by Professor Halliburton, "the quantity of vitamin necessary in the diet is infinitely small." \*

In recent years dental examinations of multitudes of school-children have been made, and one of the generalizations resulting from such examinations is that "the better the school the worse the teeth," which rather confirms the view, long held by dentists, that dental caries is not a deficiency disease; rather is it a luxury disease, depending upon the stagnation of easily fermentable and generally expensive carbohydrates.

But can we even regard the actual experiments which have been made on puppies as serious scientific evidence that lack of fat-soluble A produces dental hypoplasia? It was claimed that the special feeding of puppies had caused not only rickets but also dental hypoplasia. One might have thought that the first thing any competent experimentalist would have made sure of was that the hypoplasia had not been produced by other causes before the experiments with special feeding were commenced. Anyone acquainted with the development of enamel who is presented with a tooth showing a developmental defect is immediately interested in the conditions during, if not antecedent to, the formation of such enamel—that is to say, to conditions existing long before the eruption of the tooth. We have always recognized that rickets delays the eruption of the teeth. The specimens shown in the experiments referred to were from rickety puppies, so that presumably the eruption of the teeth had been retarded some weeks if not for some months. Now the

\* *British Medical Journal*, June 18, 1921.

enamel of the crown of a tooth is completely formed long before its eruption even in a non-rachitic subject. Consider the first permanent molar. In the human subject the tips of the cusps commence to calcify at or even before birth, and dentists recognize that hypoplasia of the cusps of these teeth is associated with pathological disturbance at a corresponding age. The rest of the enamel of the crown is then gradually formed, and the crown is complete when the child is two years of age. But I want you specially to note that this tooth erupts four years later—that is, at the age of six. Special feeding or anything else that happens to the child between the ages of two and six has therefore no relation to hypoplasia of the crown of this tooth. Although the formation of the enamel in the first molar of a dog commences just before birth, growth being much more rapid than in the human subject, it is possible that the interval between the formation of the enamel and the completion of the eruption of the first molar in the dog may not amount to more than five or six months, or to seven or eight months when rickets is present. But it appears to have been during the three to six months immediately preceding the completion of eruption of the puppies' teeth that the special feeding which was supposed to produce the hypoplasia took place. In other words, to put it briefly, the hypoplasia existed for a month or two before the rickety feeding experiments were commenced. The only evidence of any attempt to correlate the effects of the feeding and the dental hypoplasia may perhaps be found in a statement by Mrs. Mellanby that “at intervals X-ray

photographs were taken of the teeth developing in the jaws. This is not an easy matter in puppies and my results are not so successful as they ought to be." Much stress was laid on so-called "facts," but when we investigate the facts we find that they are simply unjustifiable and misleading inferences.

Here let me refer to something of an amusing nature. In some of the exhibition specimens showing hypoplasia in the teeth of puppies, which was claimed to have resulted from the absence of fat-soluble A in the diet, the lower part of the crowns of the first molar teeth—that is, the part nearest the neck of the teeth—had good enamel, although between this and the tip of the crown the enamel was hypoplastic. Now, if any part of the enamel was formed during the special feeding it must have been the part last formed—that is, the part at the neck of the tooth, because immediately the experiments were finished the jaws were treated with formalin and then preserved. Obviously, therefore, lack of fat-soluble A had cured the hypoplasia, if it did anything at all. We need not follow Professor Mellanby to Skye in his endeavours to associate the state of the teeth with fat-soluble A. His own laboratory shows us clearly all that is required to disprove his contentions.

The possible association of dental hypoplasia, rickets, and dental caries was investigated years ago by reliable observers in the medical and dental professions—not with regard to what happens in dogs, but with regard to children, which is more important, for it is this that we want to know about. Dr. G. A. Carpenter and Mr.

Denison Pedley found that in rickety children there is as a rule no deficiency of enamel,\* and further, the latter authority, as the result of a subsequent examination of 500 boys and girls in the Evelina Hospital for Sick Children, found that "there is no evidence to prove that caries is more frequent among rickety children than among those who are suffering from other diseases."† Mr. Norman Bennett in a later investigation‡ arrived at similar conclusions. He corroborated the views of previous observers, who attributed dental hypoplasia to certain diseases, such as measles, scarlet fever, whooping-cough, syphilis, dysentery, and digestive derangements not necessarily associated with rickets. Other investigators have made similar investigations and come to similar conclusions. But even though it were shown statistically that dental caries was more prevalent in children afflicted with rickets, this would not show that rickets causes or predisposes to caries. It would only corroborate what most of us believe, that excess of carbohydrate in the diet is an element in the causation of both diseases.

Consider the subject from another point of view. Hypoplasia is a very rare occurrence in the temporary dentition; and this has long been recognized by the dental profession. Recently Dr. A. T. Pitts found as a result of an examination of 5,000 temporary teeth that only about one-half per cent. were affected with hypoplasia. Yet caries is even more rampant in children's first teeth than it is in the teeth of adults, and for this reason I shall limit my concluding remarks to hypoplasia as it

\* *Lancet*, May 14, 1892, p. 1077. † "The Hygiene of the Mouth."

‡ *Trans. Ophthal. Soc.*, 1901.

affects the temporary teeth. It is admitted that when hypoplasia affects teeth it is as a rule caused by other diseases than rickets; so we may say that although one tooth in 200 temporary teeth is affected with hypoplasia, only one tooth in 1,000 is affected with hypoplasia as a result of rickets. But rickets is now recognized to result from causes other than lack of fat-soluble A in the diet, at least as a very general rule. Let us suppose, however, that in 10 per cent. of cases lack of fat-soluble A causes or helps to cause the rickets, and we arrive at the conclusion that one tooth in 10,000 is affected with hypoplasia as a result of lack of fat-soluble A in the diet. Lastly, we must remember that hypoplastic teeth do not by any means always become carious. Though hypoplasia may and sometimes does predispose to focal carbohydrate stasis, and consequently to caries, it does not always do so. Indeed, what strikes dentists most with regard to hypoplastic teeth is their ability to withstand the onset and progress of the disease, and medical men must have noted that the grossly hypoplastic Hutchinson's teeth are almost always free from caries.

So to sum up and keep to round numbers we may say that lack of fat-soluble A in the diet of children may be assumed to account for one carious tooth in 100,000.

It should nevertheless always be remembered that dental caries is a disease found as a matter of fact most abundantly among children who are fed with foods rich in fat-soluble A, and the sooner those who belabour "the importance of the infinitely little" learn to appreciate some sense of proportion the better for the rising generation.

## CHAPTER III

### ELEMENTARY LECTURE ON FOOD AND FEEDING IN RELATION TO THE TEETH

As is well known, foods contain certain elements generally referred to as proteins, carbohydrates, and fats. Proteins and fats often make up the bulk of animal foods, whereas generally speaking the carbohydrates are derived from the vegetable kingdom. It is to the carbohydrates that I would specially direct attention, because of the rôle they play in relation to decay in teeth or dental caries, which is so extremely common throughout the civilized world at the present day.

There are three groups of carbohydrates—namely, sugars, starches, and cellulose, and each of these has important bearings on dental disease. I need not go into detail with regard to them. This much, however, I should mention: the various kinds of sugar and cooked starch, if mixed with saliva and retained in the mouth, undergo chemical changes, and as the result of these changes lactic acid is produced. Lactic acid may be destructive to teeth, as it has the power of dissolving enamel and preparing a way for the parasites or bacteria which are constantly present in the mouth. Cane and other sugars undergo similar changes, and they are also to some extent liable to undergo a change of a somewhat different nature, as

certain bacteria in the mouth cause a fermentation of sugar, which results in a gummy substance being produced. Sticky sugar, cooked starch, and gum are, as we shall see, by no means harmless when they linger about the teeth. On the other hand, cellulose and uncooked starches are harmless or may even be beneficial in the food. Because cellulose is not nutritious little notice is generally taken of it, but it has some importance when we consider oral and alimentary hygiene. Cellulose is that fibrillar or fibrous network which is largely responsible for the form and consistence of vegetable foods. If all the water, sugar, starch, and protein were pressed out of our vegetable foods little would be left but cellulose. Cellulose is often said to be inert, because it does not undergo chemical change very readily. It is nevertheless the cause of much movement during the digestion of food, and particularly does it stimulate mastication. This is rather important from our standpoint, because nature keeps the mouth and other parts clean and in a hygienic state by preventing the undue lodgment or stagnation of food. So long as food and the accompanying parasites or microbes are kept "on the move" the hygiene of the mouth and alimentary canal is generally well provided for, but let food stagnate too long in crevices of the teeth or in kinks elsewhere and trouble is very likely to ensue.

We have taken into consideration the fact that cooked starch and sugar are liable to ferment and form lactic acid. There is another point in which they are similar. When sugar is eaten it becomes converted into what is called glycogen before it is passed into the system. Similarly,

when starch is eaten it becomes converted into glycogen. So that from this physiological point of view it matters not whether we consume starch or sugar. From an economical point of view, however, it is quite different, because all our cheap foods, such as potatoes, bread, and farinaceous foods generally, contain a considerable excess of starch. These foods contain protein also, and it is from these foods that we get protein in the cheapest form. As protein is absolutely essential to life, and as it is from farinaceous foods and vegetable foods, such as potatoes, that a very large proportion of the protein is derived when economy is to be considered, it follows that the carbohydrate starch is, as it were, thrown in for nothing in superabundance. It further follows as a matter of course that any money spent on buying more carbohydrate in the form of sugar is simply wasted, and, indeed, the addition of sugar to porridge, or the addition of jam or marmalade to bread is making somewhat unbalanced foods still more objectionable from the point of view of balance, not to speak of the insult to oral hygiene which it may entail. The time-honoured customs of adding fat in the form of butter or supplementing bread still further with cheese are physiologically correct, and commendable if it is desired to have a properly balanced meal. But to supplement starchy foods with sugar resembles nothing more than sending coal to Newcastle.

We may now say a few words about the teeth. You know that they are chiefly composed of a substance somewhat like bone, and the crowns are covered with a sort of cap of an extremely hard substance, called the

enamel. This enamel, however, is not really like bone. It contains no living matter. If it is injured it never grows again. It never heals up if once it is broken down. It is no more alive than a lump of rock salt. It offers no active resistance to acid, and is never immune to the action of acid any more than are the eyes or the skin.

The crowns of the teeth vary in shape, and the enamel cap is in some teeth thrown into folds or cusps, and between these cusps there are crevices and pits. Being arranged round the jaws and touching each other, crevices are formed between the teeth. There is also a crevice formed where the gum margins meet the necks of the teeth. These pits and crevices are of particular importance, because food is apt to lodge unduly or stagnate in them and trouble is likely to follow.

That there is and must be an intimate relationship between food and teeth is obvious ; but there are points in the relationship which to many are very obscure. It is well known that the enamel and the dentine have a very definite composition, and that this is most excellently adapted for the uses to which teeth are, or should be, put. This is well exemplified in human teeth. The molar or grinding teeth at the side of the mouth are put to the hardest work in grinding food, and this was particularly so in prehistoric days. It does not surprise us to find that accurate chemical examinations of these teeth show them to be richer in lime salts, or more highly calcified, than are the front or incisor teeth, which require, or at least in past ages required, even more than the molars to be able to resist blows from the front. Anyhow, this higher calcifica-

tion of the molar, or, in other words, the greater amount of lime salts in the molar teeth, is constant. Here I can imagine someone saying, "Well, if this be so it does not appear that the nutrition contained in food has much relation to the chemical composition of the teeth as we find them." And they would then be making a statement which was shown to be true by eminent investigators in the dental profession about thirty years ago. But note what follows from this: if the chemical composition of the molars and incisors be constant in America, in England, and in Germany, or wherever they have been analyzed, what becomes of the theory that the amount of lime salts in the water or the food accounts for the supposed softness of the teeth, or their liability to decay? What becomes of this theory when we find that the molar teeth are ten times more likely to decay than the front teeth?

Assuredly as far as the chemical composition of the teeth is concerned this theory may be dismissed. Of course, theoretically, if there was not a sufficiency of lime in the food the teeth might be starved, but we do not find this. There does not seem to be the slightest evidence that the teeth are starved of lime salts so long as anything approaching health exists. Some birds which have been bred to lay an egg every day larger than their own heads no doubt require special attention to the lime content of their food if a proper shell is to be forthcoming, but as a child does not require to do this, and as it takes some fifteen years to form its teeth, we may rest assured that it could get enough lime to make its teeth a hundred times over from any diet that would keep it in health at all.

Weird and varied are the diets which children get, yet even so the colour of the eye, the form of the ear, the microscopic anatomy of the skin, and the composition of the tooth are to all intents and purposes absolutely independent of these dietetic variations.

If then we say that the nutritional quality of food explains nothing whatever with regard to the constitution of the tooth, can we profitably talk about food and feeding in relation to the teeth? I think we can. In recent years there has been much talk about accessory food factors. Well, there are more accessory food factors than are dreamt of in the philosophy of cooks and physiologists. I am only going to refer to those accessory food factors which have to do with the teeth and jaws.

The first that I would mention is the physical consistency of the food. Many foods are of a firm, fibrillar consistency which stimulates mastication. Now foods of this nature are more easily digested in this form than when these same foods are reduced to such a pappy or pultaceous form that they stimulate little or no mastication. This has been clearly shown by X-ray experiments. These firm fibrillar foods, which require mastication, help to develop the jaws, because the development of bone, at least in thickness, is stimulated by pressure strain, and the bony sockets and neighbouring bone complete their normal and proper development only when they are subjected to the pressure strains of mastication or the grinding of the teeth. The teeth, on the other hand, are formed below the gums, under cover of bone, and their growth and size is quite independent of functional activity. Should they erupt

without the jaw having attained its normal development they are of a mathematical certainty bound to take up some abnormal position ; in other words, irregularities in the arrangement or crowding of the teeth are sure to occur. The disfigurement caused by irregular teeth is not the only misfortune which results from lack of development of the jaws, because irregularities in the position of teeth cause dental troubles from inducing undue lodgment of sugar, or starch, or tartar. So, too, irregularities of the teeth predispose to receding gums, and, ultimately, pyorrhœa.

This physical consistency of the food not only stimulates the normal development of the jaws ; it helps materially to keep the teeth and mouth clean. But before indicating how this results, let me refer to another accessory food factor—namely acids in foods. Although acids could decalcify the enamel of the teeth, acids of such kind and of such strength as are found in foods do not, except perhaps when they are held on parts of the teeth for a considerable time by some viscid covering, such as more or less concentrated sugar. The normal acidity of acid food stimulates a rapid flow of alkaline saliva, and thus the acids in such foods are flushed quickly out of the mouth. Moreover, acid acts on the mucous coating about the teeth, precipitates or curdles it, rendering it non-adhesive, and so allows the mucus also to be readily flushed away. To appreciate the cleansing effect of these two accessory food factors a simple experiment may be made. Take a food of the consistency referred to, which, in addition, contains some acid—for example, an apple. Take a bite or a piece of this apple and begin to masticate in the ordinary way.

Watch what happens, and you will find that the piece of apple, originally a solid lump, becomes crushed and broken up between the teeth ; the saliva is stimulated and at once begins to wash out the acid and liquid parts of the food, the dilute sugar contained in the apple and all the flavouring which is so agreeable to the palate. The pieces which are not thoroughly crushed or dissolved, and washed away and swallowed, are thrown on to the teeth again and again, and further flushed with saliva, until, towards the end of the process, all that remains of the piece of apple is little more than a completely disintegrated and harmless mop which has been aiding the saliva, the tongue, and the cheeks to clean all around and between the teeth. Suppose you have consumed an apple in this way, you may note that this is not quite the end of the process, for the saliva continues to be secreted after the apple has been consumed, and the *sève* or clean, agreeable feeling in the mouth stimulates excursions of the tongue which, with the saliva, complete the toilet of the mouth. If anything is left, if there are shreds of the apple left, probably the tongue will be specially called upon to remove them. Should it fail, as it may, especially when the teeth are irregular, it does not particularly matter, as the cellular framework of which the apple is composed is harmless from the point of view of dental caries at least.

Contrast this with a food such as a sweet biscuit, cake, chocolate, or any of the many puddings composed chiefly of starchy flour and sticky sugars. Observe how they clog the crevices, more especially of the hindmost molars ; note the absence of the mop to

promote the flushing of the saliva between the teeth ; note the absence of the clean fresh feeling which should be present at the end of a meal ; note, in addition, the somewhat viscid or clammy sweetness which lingers in the mouth ; look carefully at the crevices in the hindmost teeth, and note not only that they are probably dirty, but that the carbohydrates left are rapidly fermentable. In all probability it is the uncleanly feeling after eating sweets which to a refined taste is so disagreeable that has given rise to the orthodox method of arranging a proper meal—that is to say, making dessert follow the sweets. If the mouth is habitually left in an unhygienic state at the end of meals sooner or later one or other of two common diseases inevitably follows—these are, dental caries or pyorrhœa. When bony growth and repair are easily stimulated, and the gums are relatively firm and healthy—in other words, where children are concerned—it is the teeth which are most likely to suffer from oral malhygiene, and dental caries results. Particularly is this the case when the malhygiene is due to the lodging of sugary and starchy matters about the teeth. Adults usually do not eat so much carbohydrate in a soft and sticky form as children do. They are nevertheless not immune to disease resulting from oral malhygiene. With them the growth and repair of bone tends to become slow and feeble. The oral secretions rather than the carbohydrates tend to stagnate ; the gums become congested and loosened and secretions ooze out from them at first in their own defence, but later the process becomes unhealthy or morbid, and pyorrhœa begins to reveal itself.

No amount of antiseptics and tooth-brushing ever atones for continuous dietetic error. One or other, or more generally both, of these diseases ultimately follow in spite of all artificial aids to oral hygiene.

From a recognition of the value of these accessory food factors in the physiology and the hygiene of the mouth we can prevent dental diseases, and obviously in our choice of foods we should endeavour to select them with due regard to that pleasant and valuable feeling of cleanliness which stimulates the actions of the tongue and lips and other physiological processes. We should select those foods, particularly for the termination of a meal, which habitually leave the mouth clean and with a cleanly feeling. Taking too much sugar in coffee, or for that part in anything, is not a sign of a refined taste—quite the reverse. It is well to make agreeable observations or experiments. I would suggest one. Terminate your meal with, say, a cup of black coffee, sweetened if you like, in moderation. Note what you do with each sip; note that when you sip coffee at the end of a meal you allow the liquid to flush the mouth, and if particles of solid food linger about the teeth from the meal that has preceded, the action of the tongue and the suction of the fluids between the teeth tend to remove these solid particles. Contrast this with what happens when a drink of, let us say, milk or water is taken during a meal with the mouth full of food, and you will observe a somewhat different phenomenon. In this case the food is retained or arrested in the mouth, more particularly at the sides; a sort of channel is made in the

middle and the liquid is allowed to pass down the gullet, taking with it only the smallest amount of food. This does not stimulate the saliva and the self-cleaning processes—rather the reverse. Liquids taken during a meal are of no use for oral hygiene; still less are foods soaked in liquids, consequently children from the earliest years should never be given food soaked in milk; rather should their daily bread be toasted and thus dried and eaten in a solid state with butter, while the liquids given should be taken separately after or between meals.

We may now go a little more fully into the nature of the diseases of the teeth and the relation of food and feeding to them. Let us first consider decay in teeth, or dental caries. This disease is characterized primarily by a gradual dissolution of the hard outer part of the crown or exposed part of the tooth. It commences invariably on the *external* surface, and results from the action of acid produced primarily *outside* the enamel covering of the tooth.

The acid that attacks the enamel and starts dental caries is not the acid of, or in, the food as we take this into the mouth. The acid that attacks the enamel is generated by parasites which continuously lurk about the mouth. Here I should say a word about the parasites or bacteria of the mouth. They are very numerous and varied in their appearance and ways, but they are always with us and are much the same in all mouths, although very different in relative or absolute numbers. Some are harmless, some are useful in keeping the teeth white, others, under certain circumstances, stain the teeth; some, again,

convert cane and beet sugar into different forms of sugar, which still other bacteria convert into lactic acid, while some convert part of the sugar into a gummy substance which is not insignificant with regard to the induction of dental caries. Some bacteria, under certain circumstances, give rise to disease ; probably these same bacteria may also work in such a way that they confer immunity to disease upon us, but with these I do not intend to deal. The only kind of bacteria to which I would refer now are those which are able to produce a fairly concentrated acid from food and to keep up the supply of acid. If we *want* bacteria to live and thrive it is necessary to give them the food they require, and the mouth bacteria are quite sensitive in this way. If we want to cultivate the best bacteria for the destruction of the enamel we must, as it were, prepare the soil for them. Remember that no bacteria can live on the inorganic enamel itself, and no bacteria can produce acid from saliva, or even mucus, in sufficient amount to do the slightest harm to enamel. If we want to encourage the destructive acid-producing bacteria we require to provide them with cooked starch, or sugar, or both. That is the soil and nourishment required for stimulating their growth and for converting the mouth into a lactic acid factory.

The enamel of the tooth, be it good, bad, or indifferent, has nothing whatever to do with the bacteria which create the acid. Nor does the enamel put up any active resistance to dissolution by acid. No one could ever contend that a dead tooth, one which had lost its living pulp as the result of a blow, could set up any active resistance to dental

caries ; yet, other things being equal, such a tooth is no more liable to dental caries than the corresponding tooth on the other side of the same mouth. Fortunately, however, we can control or banish certain harmful bacteria by depriving them of the foods upon which they thrive best ; we can also counteract, or wash away, the acid formed by them so quickly that no harm will result, or we can do the reverse. We can so arrange things that the saliva is unable to wash away or neutralize the acid, and we can encourage acid production by replenishing the supply of sugar and starch as soon as the bacteria have converted previous supplies into acid. In other words, we have the control of the hygiene of the mouth in our power. But we can do nothing for the enamel except injure it, and the enamel can do nothing for itself. Possibly it may dissolve more slowly if it is normal than if it is abnormal, though there is little evidence of this, but it is quite fallacious to think that the most perfectly formed enamel resists the action of acid or the onset of dental caries. When the nature of dental caries is appreciated it is obvious that it is the *form* or shape of the teeth which is of importance in predisposing them to decay, not the quality of the enamel. When, for example, the second upper incisor tooth has well-developed enamel ridges there is then frequently a pit or crevice on the surface rubbed by the tongue, and caries is, of course, very prone to start at this point, because the form of the tooth promotes the lodgment of food and parasites, whereas the same tooth with thin enamel and no crevice never starts to decay at this particular spot. I trust I have made this clear, for the fact that the active

process which initiates caries lies outside the tooth, while the quality and thickness of the enamel have nothing whatever to do with the activity of the carious process, is the *pons asinorum* of the subject.

It is the nature of the food lodging about the teeth which predisposes the caries parasites to grow and produce acid for the destruction of the enamel. To prevent predisposition to decay, we must concentrate on preventing the lodgment of the particular kinds of food which induce the bacteria to settle under sheltered conditions and produce acid. Consider the particular sites on those teeth which are most liable to lodge carbohydrates. Caries commences on parts of the teeth which are divided into three classes—namely: (1) Caries commencing in the pits or crevices of the crowns of the teeth; (2) caries commencing between the teeth; and (3) caries commencing in the crevices formed by the gum and the neck of the tooth. All these places have one thing in common. They are sheltered from the free action of the tongue, the lips, the cheek, and the saliva. It is the free action of these, more especially of the tongue, which keeps the teeth clean and free from deleterious acid, not only by the direct mechanical removal of food, but also indirectly through the saliva and mucus. I need not pursue this subject further; suffice it to note that caries practically never commences on the lingual surface of the teeth when the gums are normal, except in those comparatively rare cases when pits exist on the surfaces of the teeth which are rubbed by the tongue. On the other hand, the larger the crevices and the more inaccessible to the tongue, the more liable are

they to decay. When we consider these points surely it is evident that the foods which are responsible for the wholesale destruction of the teeth at the present day are the sugars and highly refined and cooked starches which stick in the crevices and evade, or do not stimulate, the self-cleansing processes.

Sugar is so highly refined that we might almost say it is not a food, but a pure chemical product produced in quantity for the destruction of teeth. To be harmless to the teeth it should be well diluted with water, mixed with a fibrillar network of cellulose, which the tongue can control, and flavoured with dilute acids and aromatic substances which will stimulate the saliva. In other words, it should be taken in the form in which Nature gives it to us. Concentrated sugar in the form of sweets, jam, and marmalade accounts for far more decay in teeth than cooked starch. It is all nonsense to say that children *require* sugar beyond what is present in a natural state in fresh fruits and vegetables. Even this amount does not appear to be required, and in the light of the knowledge possessed by dentists for many years it only showed the grossest ignorance of teeth and of simple physiological principles to ration jam and marmalade in such a way that children got twice as much of either or both as adults. For no one can contend that it is twice as important to destroy the teeth of children as it is to destroy the teeth of adults. Advice to those who have long-established habits may be thrown away, but parents will often do for their children what they will not do for themselves, and this is specially true when parents know the results of dental caries from

frequent acutely painful and long-drawn-out experience. Some may perhaps think that sugars in the form of jam and sweets are not so very harmful. Perhaps you know of people who eat many sweets and yet have fairly good teeth, while others have bad teeth and eat but few. No doubt many such examples could be found. To this the reply is simply that some are less predisposed to sugar stagnation about the teeth than others. The crevices in the teeth vary in size in different mouths. The teeth in one mouth may be well arranged and regular; in another they may be irregular and crowded. Or again the palate and tongue may be relatively insensitive to lodging sugars in one and relatively sensitive in another, and, in general, we may say that the self-cleansing habits and processes vary in different mouths.

When these and other points associated with dietetic habits are taken into account, the truth emerges that in civilized countries concentrated sugar in one form or another is responsible for the destruction of millions of teeth per annum. This has long been fairly well known to dentists at least, but it has recently been shown to be true most conclusively and satisfactorily by Dr. James Wheatley, M.O.H. for Shropshire. He made an investigation about ten years ago and had the teeth of nearly 6,000 children examined. He found that there was a large preponderance of caries amongst the children eating sweets in quantity. The fewer the sweets the less the number of carious teeth and the greater the percentage of sound dentures. Among those who ate many sweets no sound dentures were ever found.

I need not now refer much to starch, the other offending carbohydrate. It is no doubt rather destructive in the form of sweet biscuits and milk, especially when eaten between meals or before going to bed, but starchy foods generally stimulate mastication and the physiological self-cleansing processes of the mouth. Moreover, starch is most frequently taken in finely divided or granular form mixed up with fibrillar cellulose. The saliva can wash through this, except when it is mixed with sugar, and carry away the liquefied starch or neutralize any acid formed from it, or it may soften or partially liquefy the starchy matter so that it may be removed by the tongue *en masse*.

Different effects of the same kinds of foods in individual mouths may also result from the fact that there are many foods in current use which have a detergent or cleansing effect on the teeth. If a food which would otherwise be destructive to the teeth is followed by a sufficiency of one of a cleansing nature, no harmful effects results. It is for this reason that every meal should be arranged in such a way that the food last eaten is cleansing in character. Even when taken together the fibrous or cleansing kinds generally render the non-fibrous or sugary kinds harmless, because fibrous matter is retained in the mouth during mastication much longer than the sugary and starchy kinds of food. Thus, for example, when mutton and jelly or potatoes are eaten, the shreddy meat is the last to be swallowed. Similarly with pork and apple sauce, or toast and bacon, celery and cheese, etc. It should be an invariable rule, however, to finish the meal with something of a cleansing nature, and for this purpose uncooked fruit

is generally the most convenient and agreeable, though at least as satisfactory results may be got by eating crisp uncooked vegetables such as celery, radish, lettuce, or shallots as a meal terminal.

The results of the teaching of these principles have been eminently satisfactory. It was first noted that when parents were taught what was correct the younger children who came under the influence of the teaching had teeth freer from caries than the elder children. Then it was noted that in the districts where a particular and keen school dentist had been, the younger children, whom he had never even seen, had better teeth than the corresponding children in those districts where the parents or older children had not been instructed in the care of the teeth. Then the war came, and where correct teaching had been carried out in a thorough and wholesale way the teeth showed a vast improvement throughout an entire county. It cannot have been solely on account of the war having reduced the sugar-supply and the milk-supply, and forcing the children to eat crusts, which in previous days would have been thrown away, for in neighbouring counties where propaganda work was not carried out the extraordinary improvement of the teeth did not take place.

Some ten or twelve years ago it was a great rarity for a dentist to find a single child of five or six years of age with teeth free from decay. Now perfect teeth in such young children are fairly common. A distinguished school dentist recently referred to this most welcome change, and estimated the number of sound dentures which he now saw among school entrants at 20 per cent.

In some districts, for example, in Shropshire, the number is much higher. This is surely a great change, for all the evidence goes to show that until about fifteen years ago dental caries had been steadily increasing. Yet even before the increasing prevalence of dental caries had been stemmed it seemed to me evident that this apparently hopeless state of affairs might, could, and should be changed. In optimistic mood I tried to encourage those who by this time recognized that the cause of the prevalence of dental caries was known and that we had it in our power to prevent the disease, and I maintained that if only we managed to reduce the amount of decay in teeth and the correlated diseases in children by 50 per cent. during the next twenty years, more good would thus be done and more suffering averted than had resulted from the triumph of antiseptic surgery. Twenty years have not yet passed, but my optimistic attitude seems to have been justified, for, in spite of all opposition arising from ignorance, apathy, prejudice, and vested interests, we are now fortunately able to point to tangible and widespread evidence that not only has the increase of dental caries been arrested, but also that there has been a substantial decrease in the disease among children.

There is another disease to which I would like briefly to refer, not only on account of its prevalence, but also on account of the fact that it is closely associated with food and feeding. I mean *pyorrhœa alveolaris*. *Pyorrhœa* is now a much dreaded disease in middle life. It should not be, because it is easily prevented when we appreciate the fact that food and our methods of feeding can keep

the teeth functional and leave the mouth in a hygienic state.

Pyorrhœa results primarily from the undue lodging or stagnation of matter about the teeth. It differs, however, from dental caries in that it is rather the secretions of the mouth than the foods which stagnate. These secretions are mucus and certain constituents of the saliva, and another physiological secretion which exudes into the space formed by the edge of the gum where this surrounds the necks of the teeth. This space at the neck of the tooth would be peculiarly liable to harbour destructive bacteria if there was not some physiological process for keeping it in a hygienic state. But in healthy mouths there is, and this physiological process is kept in proper working order so long as it is stimulated by that functional activity which is required or forced upon us when we eat suitable foods. Living cells, or phagocytes, from the blood pass into this narrow space and eat up the noxious bacteria that attempt to lodge in it. These are truly scavengers from the blood, but they frequently require the stimulus of efficient mastication to call them forth in sufficient numbers. Then, again, the liquid or serum which exudes into this space should also be kept moving or exuding. Normally this is stimulated by the movements of the tooth in its socket during mastication, and if the gum is closely applied to the neck of the tooth sufficient movement of this serum takes place. The massage of the gum which is associated with the mastication of suitable food keeps the gum clean, healthy, and firmly applied to the neck of the tooth; but sometimes the gum is not so

kept. Then, of course, the secretion tends to move slowly or stagnate, the little corpuscular scavengers from the blood fail to control the bacteria, deposits tend to form on the neck of the tooth which frequently irritate the gum still more, and provide a continual supply of most objectionable bacteria. The teeth tend to become coated with dirty deposits not only below the gum, but also for some distance above it, and these dirty deposits are infested and covered with bacteria which, although quite different from, and even antagonistic to, the bacteria of caries, are at least equally malodorous and harmful to the system generally. It might almost be said that the mouth becomes too dirty for the bacteria of caries to live.

The habitual consumption of food which does not stimulate efficient mastication and a healthy flow of saliva to clean away secretions and food débris sufficiently quickly adds to the trouble in another way. The teeth being as it were slung in bony sockets, and these sockets, being alive and undergoing incessant change, the stimulus of mastication brings blood to the bone and helps it to keep itself firm and in good repair. Similarly, the ligament or tissue which slings the tooth in its socket is kept healthy and taut. As age advances the restoration or recuperative power of the bone becomes relatively weak. Without the stimulus of mastication to increase the flow of blood, the relatively weak restorative power of the bone is still further weakened. The profit and loss of the bony account begins to show a deficit. The bone itself becomes, weak and osteoporosis sets in. The extreme edge of the bony socket fails. The ligament slinging the tooth in its

socket becomes weak and fails also. The edge of the gum ceases to be tightly applied to the necks of the teeth, and such matter and bacteria as find access to the space between the loose gums and the teeth lodge unduly, stagnate, and pour out their toxins. The weakened bone shrinks from the poison, and the weakened gum, though it may resist more or less, is liable to be invaded by the bacteria in increasing numbers as these become relatively more powerful.

Contrast this with clean and regular teeth free from tartar or stain, surrounded by healthy gum neatly and firmly encircling the necks of the teeth, stimulated in the cleansing processes natural to them by each physiologically correct meal that is eaten, and then consider whether the teaching of the physiology of oral hygiene should be neglected by physiologists any longer.

I need not pursue the subject further. Suffice it to remark that from lack of appreciation of the knowledge possessed by the dental profession—that is to say, from lack of knowledge of the physiology of mastication, of the essential function of the saliva and mucus, and of the rôle of food and feeding in promoting certain physiological processes—teeth are being sacrificed in civilized communities by the million. Physiological hygiene of the mouth is almost always conspicuous by its absence except among wild animals. I will not indicate the consequences. That is frequently done. All the same, those who tell us of the terrible state of the teeth and of the diseases and misery arising therefrom seldom tell how it might all be prevented. They seldom put themselves to the trouble of finding out what is known with regard to the physiology

of oral hygiene and the prevention of the diseases of the teeth. Rather do they say, What a shocking state of affairs ; let us encourage research ! They really discourage research workers when they inadvertently say, Let us ignore all the research work of the last century which has culminated in our present knowledge of the physiology of oral hygiene. They appeal for truth, but make no effort to elucidate it themselves. Or they say, Go to the dentist, and be treated with injections and have your teeth scaled and cleaned regularly ; and finally, when the results of continued dietetic error refuse to vanish, they say, Get all your teeth extracted ! It is all very silly. Some adults may be past all hope ; their teeth may be beyond repair ; they may not take advice, even though they know it to be true ; but, as I have said, they have this redeeming feature, they will do for their children what they will not do for themselves, and it is within their power with the knowledge which is already possessed to keep their children's mouths in a hygienic state, to keep them free from irregularities of the teeth, and to prevent dental caries and pyorrhœa, more easily and effectually than they can prevent almost any other disease.

## CHAPTER IV

### OBSERVATIONS ON THE PROGRESS OF PREVENTIVE DENTISTRY

By way of introduction, and to indicate the line of progress which I intend to follow, let me remind you that in 1530 a book was published on the diseases of the teeth,\* which warned people, if they would preserve their teeth, to avoid the use of foodstuffs "which are sweet and easily retained in the dental spaces." You will all probably admit a certain prescience in this remark. Bacteriology did not exist at this time, and the researches of Pasteur and others into fermentation in general, and into lactic acid fermentation in particular, were unknown, so that although the details of the process were still unexplored, a line of prevention was suggested which is not so very different from much that is taught at the present day. Scientific progress in prevention depends upon a knowledge of the "how" and the "why," and dentists have continuously directed their best attention to elucidating the problems presented. They have not failed to search in their own department, nor have they failed to recognize the importance of research in correlated and more fundamental branches of knowledge. Bacteriology, bio-

\* "Zeeny Artznei." Author unknown.

chemistry, biology, etc., have been called upon to throw light on this subject by the leaders of our profession.

In 1873 Sir John Tomes, whom we all honour as the father of modern scientific dentistry in England, said that caries is the effect of external causes, in which so-called "vital" forces play *no* part; that it is due to the solvent action of acids which have been generated by fermentation going on in the mouth.\*

I need not refer to the important work of Magitot in the artificial production of caries, showing how acid formed from fermentation initiated the disease, or that of Leber and Rothenstein and several others;† but that they indicated the chemical and parasitical nature of dental caries, and contributed in a marked degree to the elucidation of the subject, is admitted. Scientists, however, frequently confine their attention to one aspect of a subject, and there was much antagonism between those who believed in the purely chemical nature of the process and those who favoured the parasitic view. The late Professor W. D. Miller showed clearly the truth in both, and established beyond all doubt the chemico-parasitical nature of the disease.

Up to this time our great investigators had centred their work on the elucidation of the nature of dental caries. They felt, no doubt, that if this could be put on an incontrovertible basis, etiology and preventive measures

\* J. Tomes, "Dental Surgery," 1873, p. 734.

† On the discussion following the reading of this paper, Sir Harry Baldwin indicated that the name of the late Professor Arthur Underwood should have been mentioned, and with this I quite agree.—J. S. W.

would immediately follow. But in this there was disappointment. Indeed, the warning of the genius who wrote in 1530 had rather come to be flouted. There was a tendency to belittle the harmfulness of sugar on account of its easy solubility and to blame such starchy foods as bread and potatoes, and the supposed need of sugar for children came into vogue. Further, laboratory experiments which did not take into consideration the relative lodgeability of different carbohydrates, or of the chemico-physiological and mechanical self-cleansing of the mouth, or of the impermeability of the food by saliva or the diffusibility of lactic acid formed, led to the search for susceptibility and immunity in the teeth, thus distracting attention from the causes of focal concentration of acid—*i.e.*, the initial cause of caries.

The state of the teeth, particularly of the rising generation, compelled us to recognize that there was something wrong. It was hopeless to recommend the elimination of bread, potatoes, sugar, and fermentable carbohydrates, and to live like Eskimo. In antiseptics a solution of the problem seemed plausible to bacteriologists and those who did not trust Nature and her physiological methods. But antiseptics proved rather disappointing. It consequently became necessary to search for and expose the erroneous beliefs which obscured the truth.

The supposition that it was necessary to have "some congenitally defective point" had been invoked, and the doctrine of hereditary degeneracy of the teeth was supported by this supposition. The hereditary nature of the disease had such a hold on the profession that it was con-

sidered indubitable even by those who knew that the chemical constitution of the tooth had nothing to do with it.

Thus the late Professor G. V. Black said: "I suppose the hereditary predisposition of certain families to caries has been so generally observed that it will not be questioned, and only needs mention."\* And in Tomes's "Dental Surgery" we read: "There can be no question that the tendency to caries, whether induced by structural deficiencies or perverted functions, is strongly inherited. . . . And it would really almost appear as though bad teeth were inherited with more certainty than good teeth."†

On quite other lines knowledge had been advancing. In biology the doctrine of the transmission of acquired characters had received a rude shock, and those of us who were young at the time had no difficulty in becoming ardent disciples of the new school. Indeed, to those of us who were brought up on the theory that acquired characters were not transmitted, it came almost as a shock to find on turning to dental literature that the hereditary nature of dental caries, and the degeneracy of the teeth, should have been accepted without question.

Indeed, it became evident that all was assumption. The definite knowledge available indicated this most clearly. Black's celebrated "Investigation into the Chemical and Physical Characters of the Teeth"‡ proved that these had nothing to do with the prevalence of caries.

\* Black, *Dental Cosmos*, September, 1899, p. 829.

† "Dental Surgery," by Sir John Tomes, edited by Charles Tomes, fourth edition, 1897, p. 253.

‡ Black, G. V., *Dental Cosmos*, 1895, p. 367, etc.

Similarly, the foremost of dental microscopists of the day, Dr. Leon Williams, gave us every reason to believe that the enamel of the teeth of civilized man was just as excellent as that of his predecessors, and with regard to caries he said, "We may frequently find enamel of a markedly imperfect structure which has run the gauntlet of time for fifty or sixty years and is free from decay. We frequently find enamel decaying rapidly which from every test that can be applied to it seems perfect in structure and composition."\*

One might really have used these *facts* to support the views of Weissmann. What actually happened was that the Lamarckians used the *supposition* of the degeneracy of the teeth—without chemical, physical, and microscopic investigation—in support of *their* view!

Really the only change that has taken place in the teeth of man of a hereditary nature is probably merely a slight decrease in size of the teeth and the thickness of the enamel—changes which are all to the good in preventive dentistry.

There was another theory put forward to account for the supposed defective points in the teeth. It was to the effect that the soft food of the civilized did not stimulate the circulation of the blood in the jaws, and that consequently the developing teeth did not get their proper blood-supply. This explanation was even worse than the erroneous supposition it was invented to explain, at least in the case of the temporary teeth, because, of course, these teeth are formed before hard food is eaten.

\* Leon Williams, "Pathology of Enamel,"

Another supposition was that certain races were blessed with immunity to caries; similarly, that some families were immune. Nowadays we do not hear much of racial immunity. It is too well known how carious the teeth of native races such as Polish Jews, Kaffirs, and Maoris become when subjected to our civilized diet.

It was necessary to discover the true explanation. This was found to be that dietetic habits ran in races, and even in different families living in the same country. A recognition of this truth has allowed the heredity idea, as it used to be held, to pass quietly away, in this country at least.

Progress of a more positive kind resulted from an investigation into the nature of the food in relation to its tendency to lodge and to the hygiene of the mouth generally. It was noted that foodstuffs might be divided into two classes:\* The fibrous type, which stimulated mastication, and was not of a particularly fermentable nature, even when of vegetable origin. Though such a type of food might hang about the teeth, it at least tended to clean the mouth from the more fermentable carbohydrates. It was noted that during the mastication of such foods there was a tendency for the innutritious and non-fermentable fibre to form a kind of mop, which called, as it were, on the saliva to aid it in cleaning the teeth. The other class, the non-fibrous type, did not aid oral hygiene in this way; it was liable to be crushed into the crevices of or between the teeth and their ferment; for such "short"

\* J. Sim Wallace, "The Causes and Prevention of Decay in Teeth," 1900.

or viscous foods are generally derived from the vegetable kingdom, and are, or become by manufacture, of a concentrated fermentable nature. Sugar, jam, biscuits, cakes cornflour, illustrate this class of food. Clearly there had been a tendency to eliminate the detergent type from our diet and to increase the supply of the easily lodgeable, fermentable, and consequently unhygienic type. Generally I think it is admitted that these changes in the food account for the extraordinary prevalence of dental caries in children at the present day, as compared with the general freedom from caries among primitive races.

To anyone who was influenced by the principles of biology rather than those of antiseptic surgery, the problem became a question as to whether some detergent food might be reintroduced into the civilized dietary, rather than whether bacteria could be excluded. In this way prevention along physiological or natural lines seemed practicable, for quite independent of dental considerations the need for inert (unfermentable) but mechanically active matter in the diet seemed highly desirable to prevent the all too prevalent troubles arising from alimentary stasis.

This idea was developed, and we inferred that if the maximum benefit to the teeth from detergent foods was to be got, it was the last part of the meal which should more especially be of this character. All who are acquainted with the hygienic diet theory seem now to accept this as an obvious truth, whether in practice or precept they follow it or not; but in any case ever since I introduced

the idea\* I have never heard of any dentist being in open conflict with this principle.

The next problem to engage attention was with regard to acids in food.† Swayed by the idea that foods in their natural state could hardly be harmful to the teeth, we thought there must be something wrong in the textbook statement that foods which were acid in themselves should be avoided. Clinical evidence did not by any means show that foods, such as fruit and vegetables, were harmful, and Black, though he only made a hasty examination of several skulls, was led to the supposition "that those races which consume much sour fruit are less afflicted with caries than those living on meat and grain."

Miller's reference‡ as to how the teeth are destroyed by the grape cure no doubt appeared to justify the textbook statement. The subject seemed, however, to call for further investigation. It did not seem right to have another large and important class of foodstuffs condemned. Our knowledge of the clinical facts, our knowledge of the absence of caries among frugiverous animals, of the fibrous nature of most fruits, of the tendency of the fibrous part to become like a cleansing mop, of the effect of the flow of saliva produced by acid substances, and of the effect of acid on the mucus, provided us with the explanation *why* acid in such foods should not be destructive to the teeth. And

\* J. Sim Wallace, "Supplementary Essays on the Cause and Prevention of Dental Caries."

† J. Sim Wallace, "Solution of the Problems of Susceptibility and Immunity to Dental Caries," reproduced in "Supplementary Essays on the Cause and Prevention of Dental Caries," 1906.

‡ Miller, "Micro-organisms of the Human Mouth," p. 221.

it was satisfactory to find independent corroboration and acknowledgment of the truth of our explanation from such distinguished exponents of physiological chemistry as Professor Geis and his collaborators.

Naturally I tried to show why acid in fruit and vegetables might be considered detergent in its effects, and antagonistic to the inception of dental caries. To emphasize my views on introducing the idea of the afterflow of saliva, resulting especially from the mastication of acid foods, I said that the importance of this could hardly be over-estimated, but I fear that one erratic follower and his commercial friends *have* over-estimated its value. My intention was not to indicate that *only* acids were good for keeping the teeth clean; rather was it to show that nature provided for the eating of all kinds of natural food, and that the physiological processes secured physiological cleanliness when the foods were essentially natural in their constitution, and so I contended that it was scarcely right to consider the effects of "sugar, cellulose, vegetable acids, and bitter principles" when dissociated from each other,\* but this has not been done by tooth-paste vendors.

We may refer to another important point in this dietetic theory. It is with reference to the physical nature of fermentable carbohydrate foods. We may have a viscid or pasty mass through which saliva cannot pass, and under which acid may accumulate, or concentrate, and act on the enamel unimpeded by the buffer salts in the saliva; on the other hand, we may have the carbohydrates in the form of loose flakes and shreds round and through which the saliva

\* J. Sim Wallace, "Diet and Disease," p. 73, 1905.

may pass. Should these not coalesce or become pasty it seems evident that they can be of little harm. It is for this reason that foods mixed with sugar are so much more harmful than many of the starchy foods such as bread. Unfortunately sugary foods are by no means so easily diluted and washed away as was once supposed.

Consider our knowledge at the beginning of the century, when Miller said : " The question of the different susceptibilities of different teeth to caries still remains an unsolved problem."\* Now if we can show that the known susceptibilities of the various teeth conform to and are the result of conditions which we have explained with relation to susceptibility to caries in general, then not only will the solution of an unsolved problem be an interesting addition to our knowledge, but it will be an argument of considerable importance in establishing the truth of the general contention which we have already advanced. . . . " We should remember the direct effect of mastication ; the indirect effects of mastication—*i.e.*, the muscular contractions of the tongue, cheeks, and lips, and the influence of them on the fluids of the mouth ; and the effect of ptyalin in dissolving the carbohydrates, and thus facilitating the removal by swallowing of the converted starch.

" Let us first direct our attention to the lower incisors and canines. These teeth are peculiarly immune to caries. Their shape is such as to render the lodging of food practically impossible, except on their approximal surfaces, for not only are there no crevices in which food might lodge, but the motions of the lower lip and tongue are

\* W. D. Miller, *Trans. Odont. Soc.*, March, 1903.

greater over the labial and lingual surfaces than over any other teeth. Leaving other things out of account at present, the fact that the mandible and the tongue are relatively less mobile posteriorly, the greater susceptibility for food to lodge must be towards the back of the mouth. So, too, the saliva is for similar reasons caused to pass between these teeth more fully than it does towards the back of the mouth." I need not weary you with reference to the premolars or molars, with their pits and crevices, which are relatively difficult for the tongue to clean, since nothing is more obvious when our theory is grasped than the explanation of the different susceptibilities to caries of different teeth. Moreover, I have already referred at length to this subject nearly twenty years ago,\* and have practically nothing to add beyond, perhaps, calling attention to the extreme freedom from caries of the lingual surfaces of the teeth, except when, as occasionally happens, pits are present, or when the gums have receded.

It will surely be admitted that we have progressed a long way since it was considered "very surprising"† to hear that the incisor teeth were less highly calcified than the molars, which are relatively highly susceptible to caries. Now to us it is perfectly obvious that it is the external configuration of the tooth that may predispose to carbohydrate stasis, and consequently to caries, while we see equally clearly that the internal structure and composition

\* "Dental Record for 1904." Reproduced in "Supplementary Essays on the Cause and Prevention of Dental Caries," p. 45 *et seq.*

† J. H. Mummary, "Notes on Dentine and Enamel," *Trans. Odont. Soc.*, p. 135, 1896.

of the tooth have nothing to do with the active process ; they may merely influence its rate and progress.

Since caries results primarily from the fermentation of carbohydrates *outside* the teeth, it is the retention areas caused by the form of the teeth which may determine the sites of caries when conditions are favourable to its production. These are common to all races past, as well as present, but since we attribute the prevalence of caries to the changes in the food of man from the detergent to the lodging and fermenting type, it is evident that beyond elucidating the subject we dental surgeons are hardly appropriately placed for distributing the knowledge directly to those whom it may concern. It is rather the physiologist, the food specialist, and medical men generally who could do this if they had the necessary knowledge. In other words, to make progress in preventive dentistry it is necessary for us to teach physiologists and, directly or indirectly, other members of the medical profession the elements of the physiology of oral hygiene. What progress can we record in this? Well, with regard to physiologists we have made remarkably little. Professors Geis and Noël Paton have no doubt helped us, and one or two others are in sympathy with our views. But on the whole physiologists have done nothing. They do not even recognize that the essential function of the saliva has been discovered and that this is not the digestion of starch.\* Let me refer to the latest effort which has been made. In it we can see perhaps a glimmer of recog-

\* J. Sim Wallace, "The Physiology of Oral Hygiene," *British Medical Journal*, October 29, 1921.

nition of our views. In a book recently published on "Physiology for Dental Students" we find at least a faint allusion to the detergent action of certain foods, and to the fact that some other foods do not stimulate mastication, but are passed through the mouth after merely receiving a general squash between the dorsum of the tongue and the hard palate. Nevertheless the physiology of mastication is passed over in such a way that the essential action of the process is entirely omitted, and the old view remains that "the food is gathered up into a bolus and swallowed."\*

With regard to the saliva, its least essential function comes first, and is the more elaborately treated, while its most essential function comes last, and these are most inadequately presented. All reference to such important subjects as chemiotaxis, true salivary corpuscles, the passage of leucocytes into the gingival trough, and phagocytosis is completely omitted. It would really appear as though the little information given with regard to the physiology of the saliva was intended for students who were determined to learn nothing about the teeth lest it might hamper their chances of getting through an examination in which they well knew that a dental question would not be asked. With regard to the mucus which is so ingeniously adapted for the maintenance of oral hygiene nothing is said at all beyond the mere mention of the word. Yet this book of physiology for dental students gives at least five pages on the physiology of the ear, and nine pages on the physiology of the eye. As I have

\* A. G. Curzon-Miller, "Physiology for Dental Students," p. 48.

already indicated, however, we have had the co-operation of other medical men in increasing numbers who have materially contributed to the advance of our knowledge. I need only instance here Dr. Harry Campbell's\* most valuable contributions on mastication and the evolution of man's diet. Other influential writers, such as Drs. Truby King,† G. A. Sutherland,‡ and John Thomson,§ have done much to bring home to children's specialists the principles of dietetics which make for oral hygiene and freedom from dental diseases and their sequelæ. When we turn to consider what progress has been made among those who in a sense are most practically concerned with preventive dentistry—I mean medical officers of health and school medical officers—we find the most welcome encouragement. In his annual report for 1910 || the Chief Medical Officer for the Board of Education threw the weight of his authority and authoritative position on the side of the work done by the dental profession. His subsequent reports gave us further help, and his terse summaries of our views have done much to spread knowledge with regard to causation and prevention. Even where treatment was concerned he insisted that if permanent results were to be obtained this too must be placed on a preventive basis.

Further, the Society of Medical Officers of Health have

\* "Observations on Mastication," *Lancet*, July 11 and 18, 1903, etc.

† "Feeding and Care of Baby" and "The Story of the Teeth."

‡ "Treatment of the Diseases of Children."

§ "Guide to the Clinical Study and Treatment of Sick Children."

|| Annual Report of the Chief Medical Officer of the Board of Education, 1911.

officially endorsed our views. It elected a committee to draw up a leaflet on the prevention of decay in teeth. After considerable deliberation this leaflet was unanimously approved of by the committee and adopted by the Council of the Society.\* Truth gains easy converts just when and where it is wanted, and no more practical and satisfactory step in the progress of preventive dentistry could be hoped for.

Now let me refer to the work of Dr. James Wheatley, M.O.H. and School Medical Officer for Shropshire. About 1910 he started his campaign of prevention. He lectured to the medical men in his county, to the teachers and health workers, and prepared leaflets for their guidance and for the guidance of mothers with young children. I need not trouble you with details of the now famous results obtained by his appreciation and application of our ideas; suffice it to say that since he has been able to increase the number of school entrants with perfect teeth from 5 per cent. to 49 per cent. in ten years, we can rest assured that the future will bring even more excellent results. To those who kept on repeating that we did not know the cause of the prevalence of caries or how to prevent it, his results no doubt came as a shock, and to those who, while admitting that we did know the cause, said that people would not follow our precepts, we may commend the study of his figures. No doubt some are more amenable to instruction than others, and for this reason, as we might expect, the teeth of the children in the Atcham Scattered Homes appear even to excel those of

\* *Public Health*, April, 1923.

the children in the rest of the county of Shropshire. That there was on the whole an improvement in the teeth of children as the result of war conditions and the diffusion of knowledge has been generally noted. But in Shropshire, where a vigorous campaign for prevention had been carried on for some years before the war, the results have been far more marked than elsewhere.

Even allowing a margin for possible error, it must surely be admitted that Dr. Wheatley's figures corroborate on a large scale the excellent results which certain dentists\* were able to record with regard to individual children under their own care or under the care of others who would follow our dietetic precepts. It may now be seen to be a calamity that such precepts were not made known and acted upon by all medical officers of health a decade or so earlier.

The path of progress has not been an unchequered one. At first the indifference of the responsible members of the dental profession retarded progress. It was not until 1909 that even a moderate acceptance of our ideas was introduced into any textbook for dental students.† A few years later, however, Mr. Norman Bennett incorporated our views of causation in his "Science and Practice of Dental Surgery,"‡ to my complete satisfaction at any

\* J. Sim Wallace, "Prevention of Dental Caries," 1911. F. M. Holborn, "The Cause and Prevention of Dental Caries," *British Dental Journal*, May 2, 1921. R. S. Sanderson, "Prophylaxis in General Practice," *British Dental Journal*, October 2, 1922. T. Hunter, C.B.E., "Dental Hygiene," 1921.

† Sir Frank Colyer, "Dental Surgery and Pathology."

‡ N. G. Bennett, "Science and Practice of Dental Surgery."

rate. Then the war broke out, and this, of course, interfered seriously with progress, although the scarcity of sugar and the knowledge with regard to its harmful effects on the teeth gave rise to the publication of pamphlets such as "Why worry about Sugar?" and so on. But if the war hindered propaganda work with regard to the prevention of caries, some salutary lessons have since been learnt concerning the supposed need of sugar and fat-soluble A vitamin for children.

Naturally since the theory has been authoritatively accepted there has been a certain amount of opposition from those whose views were discarded. Moreover, there have always been those who could not be bothered with a theory which presented some trouble in carrying out, and in becoming satisfied with its application in individual cases. Knowledge and patience are necessary in unraveling the results of dietetic error which are often presented to us. No two foodstuffs are the same, and even although we may classify foods as lodgeable and fermentable on the one hand, and detergent on the other, there are very considerable variations in such characteristics in both classes. Nor have we simply to deal with one particular foodstuff at a time. In the diet of almost everyone the detergent and lodgeable types are so inextricably associated that it is in many cases well-nigh impossible to come to any conclusion with regard to the share different articles of diet have in determining the occurrence of the disease. It is, indeed, only when some long-continued error is pronounced, and not counteracted by detergent foods, that we are able to show clearly the truth of our theory. The

arrangement of the meal requires, as a rule, to have consideration even when there is not supposed to be any arrangement in it at all. Then, again, what we may call the static variation in the teeth, such as the depth of crevices, abnormal pits, faulty arrangement, and receding gums, have to be taken into consideration. Lastly, variations in the physiology of oral hygiene in different people must receive their share of attention. These are seldom or never noted by those who look for some mysterious immunity in the tooth. Yet they exist, and often account for much when dealing with the same diet in different people. Mr. F. Breese\* showed that the amount of lodging food in different children's mouths varied greatly, even though the actual food eaten was the same. The varying amount was observable when the meal was finished. The quickness of the self-cleansing process indicated that this was largely mechanical, depending on the arrangement of the teeth and on the cleansing action of the tongue, cheeks, and lips differing in different children.† The importance of varying dietetic habits may be illustrated by considering the effects of eating grapes. When grapes are eaten by some people the skin is burst by the partial closing of the teeth. To avoid the pips the teeth are not fully closed. The skin is just squashed somewhat and then ejected. If grapes are eaten persistently in this way, or if the juice is expressed for the patient, we should not be surprised if the effect were dele-

\* F. Breese, *British Dental Journal*, 1913.

† H. W. Breese, "Oral Hygiene," *British Journal of Dental Science*, June, 1922.

terious.\* On the other hand, some people's dietetic habits with regard to grapes are quite different. Even in this country grape skins and pips may be masticated, the fibrous skin acting to a slight extent as a mop, and the crushed pips acting effectively in stimulating the tongue and saliva to self-cleansing activities after the grape juice is swallowed.

There are, of course, varying conditions in different mouths which may require to be considered, notably, for example, serous secretions favouring bacteria which supplant acid-forming bacteria. And, indeed, when we consider the complexity of foods on the one hand and of the physiology of oral hygiene on the other, can we wonder at impatient investigators yearning for some mysterious immunity which would allow us to dispense with these complexities?

It would, of course, be delightful to discover some silvery nitrate which would keep the teeth a pearly white and allow the world to defy the dirt which harbours the acid-forming microbes. It would be delightful to discover a subtle something which would allow us to play dietetic ducks and drakes, and yet defy the penalties. Is not the idea of some unrecognized immunity to dental caries, of which there is no evidence, simply a case of the wish being father to the thought? To me the wish is unsavoury and heedless of the very thing we want—that is, the detailed and authoritative elucidation of the physiology of oral hygiene.

In addition to contending that our dental view was not

\* Miller, "Micro organisms of the Human Mouth."

correct, efforts have been made to maintain other hypotheses. New views such as the osmosis, the thyroid, and the endocrine theories have been advanced, while attempts have been made to revive the vitalist and vaccination hypotheses. None of these has been very seriously taken up. The vitamin theory is different in that it shone with such splendour that medical research workers seemed blinded to dental research, and even the Royal Society bedazzled itself with the supposedly brilliant results. It had long been my contention that we could not judge foods properly by their caloric value and that accessory food factors such as physical consistency, viscosity, lodgeability, fermentability, acidity, etc., must be taken into account, so at first I rather welcomed vitamins. But with regard to fat-soluble A I began to see it looming too large on the horizon. That it might be the cause of rickets may not have disturbed me, but when it was claimed that lack of fat-soluble A was the fundamental cause of rickets, dental hypoplasia, and dental caries, I began to think investigators must be peculiarly ignorant of the researches which had been carried out long years ago. Distinguished dentists\* had, of course, thought of the possible association of rickets and dental caries, but their investigations negated the idea that there was any special association, and clinical evidence did not lend much if any support to the view. Moreover, about thirty years ago Black's memorable investigation showed that the calcium content of the teeth had nothing to do with

\* Denison Pedley, "The Hygiene of the Mouth." N. G. Bennett, *Trans. Ophthal. Soc.*, 1901.

predisposition to dental caries. Nevertheless Professor Halliburton, in 1921, while speaking of rickets, referred to the condition of "bad teeth" as closely allied to it.\* Professor Mellanby made similar implications, and even as late as July of last year said that the "eradication of rickets . . . would improve the teeth of the people of this country beyond recognition."† Many years ago we had considered that hypoplasia might occasionally result from rickets, but, of course, as a cause of the widespread prevalence of caries it is quite negligible. I have not time to refer to the sorry fate of the original fat-soluble A theory of the causation of rickets; nor to the collapse of the original fat-soluble A theory of dental hypoplasia and caries. You know that the experimental deficiency diet which was supposed to have produced the hypoplasia was given after the hypoplasia had taken place; that the hypoplasia became cured during the deficiency diet; and thanks to the investigation of Mr. A. T. Pitts we were able to show that, even supposing hypoplasia might be caused by this deficiency diet, it could only be held to account for one carious tooth in 100,000 in temporary teeth.‡ Microscopic substitutes for the fat-soluble A theory of hypoplasia need hardly be considered, and Mrs. Mellanby's modest claim that her work shows Miller's chemico-parasitical theory to be "comparatively unimportant"§ may be passed without comment.

Although this vitamin theory revived the old untenable

\* *British Medical Journal*, June 18, 1921.

† *Ibid.*, November 4, 1922.

‡ *Ibid.*

§ May Mellanby, "The Relation of Caries to the Structure of the Teeth," *British Dental Journal*, January 1, 1923.

and discarded belief that the incidence of caries depended on the quality of the tooth itself, we may comfort ourselves that the discredited experiments and views have undermined the other untenable hypotheses; in fact, we appear to be getting tired of anything but the simple truth, and it is pleasant to note that even those who espoused the vitamin theory have now acknowledged we were "right from the first,"\* while those who "continued quietly teaching and standing by the truth first and long ago discovered"† in England have been acclaimed for their work in furthering the cause of preventive dentistry.

Recognizing the confusion caused by conflicting theories originating from ill-informed quarters, some students of the subject who were convinced that the problem was solved thought that a Government inquiry should be made. My friends Dr. James Wheatley‡ and Dr. W. E. Nicholls Dunn§ insisted strongly on the necessity of this. As you know, a committee has since been appointed by the Medical Research Council in consultation with the Ministry of Health.

Naturally on this committee the name of Mrs. Mellanby appears; she could be relied on for "facts" unprejudiced by the researches of mere dentists. Professor Halliburton, who had given his blessing to the vitamin theory, was elected chairman. Four other medical men without dental qualifications were elected, and two dentists who had helped Mrs. Mellanby in her research were graciously

\* C. W. Saleeby, *The Outlook*, November, 1922.

† *Dental Record*, January, 1923.

‡ *British Dental Journal*, 1920. § *Lancet*, December 21, 1918.

permitted to serve on the committee. A medical friend one day asked me what I thought of the committee. I said, "Suppose the Government appointed a committee to inquire into the cause of mumps or measles, composed of five dentists, two medical men with dental qualifications, and the wife of a dentist, what would *you* think of it?" His answer was: "That it would be an unmitigated insult to the medical profession." "Well," I said, "possibly we dentists think on parallel lines."

Now the question arises, What useful work could a committee perform? If it were judicially constituted it might take evidence, and adjudicate between two or more schools of thought, and make a report giving its conclusions. This might well be a useful procedure. Or a committee might be elected to try to find out something which was unknown, but it is difficult to think that this would be of much use. Let me illustrate: Suppose it were asserted that a new element had been discovered, but that there was a conflict of opinion on the subject; a judicial committee could take the evidence and give judgment.

Suppose, on the other hand, it was believed that some new element would be discovered, what use could there be in appointing a committee?

When the Caries Committee was elected, no doubt it considered the procedure and method which it would adopt. So far it would appear that the ordinary method of taking evidence from expert or other witnesses has not been followed. The Committee seems to have come to the conclusion at once that the cause of caries was unknown,

and that the whole subject required reinvestigation. In fact, this committee has become a research committee, the first function of which appears to be to try to show the need of its own existence. We have now its first report,\* admittedly published before it knew the cause of caries. Thinking, I suppose, that "bad teeth" were to blame, it naturally directed attention to them, in spite of the fact that every intelligent dentist knows quite well that caries is a chemico-parasitical process commencing outside the tooth. The report draws attention to the histology of the tooth. Now the histological structure of teeth is interesting and important, but from the point of view of caries its importance is derived from the fact, not that it has anything whatever to do with the cause of caries, but that it may influence its progress. Thus, for example, caries may spread out and progress more rapidly in the dentine after a breach has been made in the enamel if the dentine is ill-calcified and full of interglobular spaces. Again crevices on the enamel of a molar favour the stagnation of carbohydrate and fermentation. If this is hypoplastic, acid formed from carbohydrates tends to spread relatively easily and soften or undermine the enamel. This, then, is readily ground down and washed away during mastication, so that nothing may be left but a polished surface of dentine which does not favour the undue lodgment of carbohydrates. Thus the progress of the disease may be *mechanically arrested*. Yet a well-formed tooth in similar circumstances may be completely destroyed.

\* J. Howard Mummery, "The Structure of Teeth in Relation to Dental Disease."

What happens as a very general rule, after the enamel is broken by caries, is simply that the pre-existing cause has a *better* chance of acting on the tooth and causing its destruction.

If we are right in believing that the cause of caries is outside the tooth and continues to be so until the enamel is broken down, then this first report of the Caries Committee is most prejudicial and misleading, for the idea that there is something in the quality or vitality of the enamel itself which is answerable for immunity to caries is implicitly fomented.

We have seen that immunity does not exist in the enamel, and need not be assumed, yet sensational observations by such writers as von Beust about "antibodies" derived from "plasma" coursing through imaginary "vascular channels" in the enamel to combat the bacteria, are solemnly introduced into a report purporting to be a summary of existing knowledge! It is wonderful what crystal gazers, equipped with powerful lenses, can see and think probable, especially when the tissue or retina is deeply stained with herring rouge.

The points to which attention might well have been directed are three in number: The first is that the enamel of all teeth, whether thick or thin, old or young, good or bad, is decalcifiable by lactic acid; the second is that enamel is utterly incapable of secreting antibodies or any other thing to prevent the fermentation of carbohydrates lying on its surface, or in any way to secure immunity from the action of acid applied to its surface; the third point is that the external configuration of the crown of the

tooth, and the arrangement of the teeth in relation to each other, and to the gums, should be fully described because these predispose to the localization of the fermentative processes which initiate caries. If we are right, then the report that has been issued would seem to be a pitiable illustration of how the obvious truth may be obscured by dilating on microscopic and other details which are irrelevant to the essential facts and our existing knowledge. It is easy to collect conflicting and absurd opinions on any subject in any profession, or to cater to the popular and relatively soothing idea that teeth decay or not according to whether they are intrinsically good or bad. It is not so easy, apparently, to avoid misleading inferences and suggestions until the knowledge of the cause of caries is clearly grasped.

The report is deplorable in yet another way. It, together with its introduction, would inevitably lead anyone who knew no better to think that the dental profession was remarkably ignorant of the cause or causes of caries. It might flatter the vanity of the committee to commence with a subject in which nothing but ignorance prevailed and conclude with its complete elucidation, but this would involve "the demoralization of literature as well as the confusion of the records of science."

For, notwithstanding details, we already know the cause of caries better than we know the cause of almost any other disease, and this has been expressly maintained by medical authorities who, like Dr. Wheatley,\* have studied the subject.

\* J. Wheatley, "Dental Caries as a Field for Preventive Medicine," *Public Health*, August, 1912.

Let me try to summarize our existing knowledge. Caries is a chemico-parasitical process primarily involving the fermentation of carbohydrates. What determines the production of caries (*i.e.*, the cause of caries) is unduly prolonged lodgment of carbohydrates under conditions favourable to the production and accumulation of acid in sufficient strength to destroy the enamel. (Carbohydrates which do not lodge or ferment or cause other carbohydrates to lodge unduly do not cause caries.) Besides the bacteria which produce acid, others generally take a share in the process; for example, the bacteria which convert the disaccharides into monosaccharides, and those which cause manitic fermentation. The exciting cause (acid-forming bacteria) is primarily outside of and altogether independent of the histological structure of the tooth.

There are several predisposing causes, but these may be summarized by saying that they are all those conditions which favour the location and action of the exciting cause—*e.g.*, crevices, normal or abnormal pits, irregularities of the teeth, receding gums, bad dietetic habits, and faulty response of the physiological self-cleansing processes of the mouth. To these must be added the quality of the food which lodges (fermentability, impermeability, and viscosity), as this is the soil which attracts and encourages the proliferation of the acid-forming bacteria, and, moreover, may impede the protective and self-cleansing physiological processes which keep the teeth free from decay. These predisposing causes are all external to, and independent of, the histological characteristics of the teeth. Alto-

gether we may say in two words that the cause of caries is carbohydrate stasis.

Finally, let me say that the recognition of these facts, and the elucidation of the physiological processes which prevent such stasis, together with the results obtained by the application of our knowledge, have, I believe, made England the cradle, the hope, and the pride of preventive dentistry.

## CHILD WELFARE\*

### POLITICS AND PHYSIOLOGY

IT is doubtful if the expenditure of public funds for the promotion of research is ultimately likely to be well spent. A judicial committee to inquire into the value of original research work, and to pay for this if valuable, after it has been done, might stimulate original research, although justice is what research workers appreciate most and no doubt always will. A Government's primary function is the administration of justice, and State subsidies are, as a rule, of the most doubtful value. Moreover, unless we want to follow the disastrous example of Germany, it would seem inadvisable to discourage independent individual enterprise by putting research work into the hands of a bureaucracy. The records of the past have at times been tarnished by injustices even to the great benefactors of humanity, and to prevent this in future, whether by effective criticism or otherwise, should be one of our chief aims.

Probably the most useful work which a well-chosen committee could do would be to inquire into the merits, or rather demerits, of theories which, having gained currency, might be supposed to be doing widespread harm. There

\* J. Sim Wallace, M.D., D.Sc., L.D.S., "Child Welfare." London : Baillière, Tindall and Cox, 1919. Pp. x+102. Price 5s. net.

are many such theories, and it would be well to have most of them clearly exposed, together with the evidence upon which the committee based its report. Surely the sooner a theory injurious to public health is publicly exposed the better.

It is particularly desirable that this should be done when one and the same profession, or different branches of the same profession, are in open conflict with regard to what is authoritatively taught to students.

On account of the interest and importance which "the modern school of medical men interested in the prevention of disease in general" attaches to the new theory of the primary function of the saliva, a committee composed chiefly of medical officers of health, taking evidence from physiologists and dentists and other expert witnesses, might well, in the light of the new evidence, inquire into the older beliefs which are still so widely taught. This could be done, no doubt, without discouraging individual research workers. The following press notices on "Child Welfare" indicate not only the unanimity with which the new views have been greeted, but also the urgent need of deciding what should be taught:

"There can be, in our judgment, no manner of doubt that the views here enunciated are in the main sound, and that their wider recognition is eminently desirable. . . . It would be a good thing if doctors generally would take to heart some of the truths."—*The Practitioner*.

"The book deserves to be widely read, for the author not only knows what he is talking about, but shows the prevailing ignorance of the subject of hygienic diet both

inside and outside the medical profession, not excepting the physiologists.”—*Clinical Journal*.

“The physiologists, Dr. Sim Wallace contends, are the worst culprits, since they do not teach the Alpha and Omega of oral hygiene. . . . He tells us the use of saliva is not primarily to insalivate the food, and its ptyalin possesses little digestive function. Saliva is the ever-present mouthwash, which, with the aid of the tongue and jaw movements, removes particles of débris. So, also, mucin does not lubricate a hypothetical bolus and speed it on its way down the œsophagus, but assists in the aseptic toilette of the mouth. . . . That oral hygiene is pretty generally unknown and its importance unrecognized by the average general medical practitioner is indisputable, but whether the fault lies with the physiologist rather than with the clinical physician we think may fairly be discussed.”—*British Journal of Dental Science*.

“He brings forth evidence which is conclusive that the prime function of the saliva is not so much to act as an adjuvant to digestion, but a protective secretion to cleanse the mouth and preserve the teeth by controlling fermentation. We may remind the author that to change old-established customs and modes of thought is ever a slow process, but we can assure him that his words have not fallen on deaf ears.”—*The Medical Officer*.

“The whole matter of the oral secretions is badly in need of revision. . . . The old physiology-book fallacy of the action of saliva as of importance as a digestive process is dying a lingering death. . . . If, as Dr. Sim Wallace

contends, the mucus is ingeniously devised for oral hygiene, we are more than ever driven to the conclusion that with a rational diet nature has done all that is necessary for conserving a healthy state of the teeth and mouth.”—*New Zealand Dental Journal*.

“Dr. Wallace regards the main function of the ptyalin in saliva to be to dissolve and so assist in the removal of particles which would otherwise lodge in the mouth, and this view is far more reasonable than the older teaching which regards the salivary glands as mainly digestive in function.”—*Maternity and Child Welfare*.

“He has an excellent ‘dig’ at the physiologists, who, he rightly maintains, still continue to propound erroneous doctrines regarding oral hygiene and the physiology of mastication. . . . Referring to the altogether erroneous idea that the saliva is a starch-digesting secretion, the writer says that if physiologists would look into the matter . . . they would confer an inestimable boon on the community.”—*British Journal of Children’s Diseases*.

“The pathology and etiology of caries are sufficiently well known to support effective measures for the prevention of this disease, which is probably more easy to prevent than any other. . . . He has some hard words to say about those responsible for educating the medical man. . . . There are signs that an attempt is to be made to deal with this problem by the creation of a public dental service. We draw the attention of those responsible for the creation of any service to this little book, for it will help them to recognize that the right way

lies not in starting curative centres, but in the broadcast dissemination of the means of prevention. Thousands of pounds of public money may thus be saved and dental disease effectively combated.”—*Lancet*.

“The aim of this book is to show to the medical profession the root cause of dental caries in children. He contends that the physiology of dietetics and of oral hygiene is wrongly taught by almost all physiologists. Dietetics is not merely a question of calories and vitamins. . . . Ptyalin, as we all know, digests starch, but Dr. Wallace considers that this function is not to aid digestion, but to help to remove carbohydrate débris from the cracks and crevices of the mouth. These and other interesting conclusions are strongly supported by trenchant arguments, and the usefulness of the book is added to by several very practical diets for children. One would like to see some physiologist take up the cudgels in support of their teachings.”—*Guy's Hospital Gazette*.

“Somewhat provocative in tone, but quite admirable in substance.”—*The Hospital*.

“Il précise le rôle physiologique du mucus buccal et de la salive, qui, contrairement à l'opinion courant des physiologistes, jouent avant tout le rôle de nettoyage de la bouche. . . . C'est ce rôle que Sim Wallace, qui le premier l'a établi, définit dans tout sa portée. L'auteur d'ailleurs, au cour de tout son livre, fait un vibrant appel aux médecins, et surtout aux physiologistes, pour qu'enfin l'on veuille quitter les erreurs d'antan, causes de tant de misères et de tant de désastres. . . . ‘Prévenir vaut mieux que guérir.’ Ce sera l'éternel honneur du Dr. Sim

Wallace d'avoir été le premier à établir cette vérité avec toutes ses conséquences logiques pour le domaine buccal. . . . Et nous souscrivons ce qui disait 'The Statist' à propos du livre précédent de l'auteur : ' Nous avons la conviction absolue que Sim Wallace est dans le vrai, et que son œuvre produira pour l'humanité toute entière plus de bien que le travail de tout autre contemporain.' ”—*Revue Belge de Stomatologie*.



This book must be returned to  
the Dental Library by the last  
date stamped below. It may  
be renewed if there is no  
reservation for it.

May 10

RK 61 W25 1923

Author Wallace, James Sim

Title Oral hygiene

H.R. Abbott  
Mem. Lib.

Cop. B

DATE.

NAME OF BORROWER.

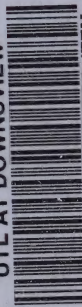
University of Toronto  
Cop. B. Library

H.R.A.

DO NOT  
REMOVE  
THE  
CARD  
FROM  
THIS  
POCKET

Acme Library Card Pocket  
Under Pat. "Ref. Index File"  
Made by LIBRARY BUREAU

UTL AT DOWNSVIEW



D RANGE BAY SHLF POS ITEM C  
39 04 11 23 10 005 8